ELECTRICAL CONDUCTIVITY OF AQUEOUS SOLUTIONS

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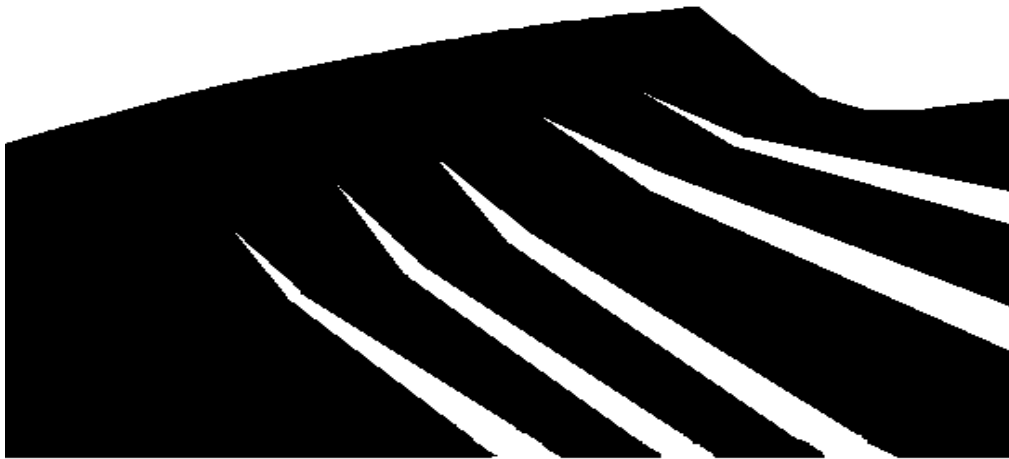
APPROVAL FOR RELEASE

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Los Alamos
Yucca Mountain Site
Characterization Project

HISTORY OF REVISION

REVISION NO.	EFFECTIVE DATE	PAGES REVISED	REASON FOR CHANGE
R0	04/21/95	N/A	Initial procedure.
R1	01/09/97	All	Revised to comply with LANL-YMP-QP-06.3 requirements.

Los Alamos
Yucca Mountain Site Characterization Project

ELECTRICAL CONDUCTIVITY OF AQUEOUS SOLUTIONS

1.0   PURPOSE

This detailed technical procedure (DP) describes the process for determining electrical conductivity for aqueous solutions produced in conjunction with the Yucca Mountain Site Characterization Project (YMP) Water Movement Test.

2.0   SCOPE

This DP applies to YMP personnel who measure electrical conductivity as part of the YMP Water Movement Test study for Los Alamos National Laboratory (LANL).

3.0   REFERENCES

LANL-YMP-QP-02.7, Personnel Training
LANL-YMP-QP-03.5, Documenting Scientific Investigations
LANL-YMP-QP-12.3, Control of Measuring and Test Equipment and Standards
LANL-YMP-QP-17.6, Records Management
LANL-CST-DP-103, Identification, Storage, and Handling of Samples for the Water
                 Movement Test

4.0   DEFINITIONS

4.1   Electrical Conductivity

Electrical conductivity is the ease with which an electrical current will pass through a material, in this case an aqueous solution. It is dependent upon the presence of ions (total and relative concentrations, valence, and mobility) and upon temperature. Units are siemens or reciprocal ohm (mhos) per meter, at a specific temperature, usually 25°C.

5.0   RESPONSIBILITIES

The following personnel are responsible for the activities identified in section 6.0 of this procedure:

- Principal Investigator (PI) for the Water Movement Test

- YMP personnel performing work to the procedure

6.0 PROCEDURE

The use of this procedure must be controlled as follows:

- If this procedure cannot be implemented as written, YMP personnel should notify appropriate supervision. If it is determined that a portion of the work cannot be accomplished as described in this DP, or would result in an undesirable situation, that portion of the work will be stopped and not resumed until this procedure is modified or replaced by a new document, or until current work practice is documented in accordance with QP-03.5, subsection 6.1.6.

- Employees may use copies of this procedure printed from the controlled document electronic file; however, employees are responsible for assuring that the correct revision of this procedure is used.

- When this procedure becomes obsolete or superseded, it must be destroyed or marked "superseded" to ensure that this document is not used to perform work.

6.1 Principle

Under some conditions, electrical conductivity measurements of soil solutions provide a surrogate measure of evapotranspiration and, therefore, of infiltration rates. Evapotranspiration of soil porewater causes an increase in ionic concentration and total dissolved solids with increasing depth. This increased ionic concentration and total dissolved solids is indicated by greater electrical conductivity. However, any relationship between electrical conductivity and salt concentration (or osmotic pressure) is only approximate due to the marked difference in equivalent weights, equivalent conductivities, and proportions of major solute in samples.

6.2 Equipment and Hardware/Software

Equipment, materials, and chemicals needed to conduct electrical conductivity measurements are listed below. Laboratory glassware and plasticware are used for preparation and storage of standards and samples. Class A volumetric labware are used in the preparation of standards. Not all of the items are absolutely necessary. Items or components equivalent to those listed below may be used provided they perform the same function with an acceptable level of performance as judged by the user or the PI.

- Analytical balance with minimum 100 gram capacity and 1% sensitivity for quantities greater than 5 grams (e.g., Mettler Model H54AR)

- Conductivity meter, preferably with temperature correction, with an accuracy of 5% and a range of 0 to 15 mS/cm (e.g., ORION Model 120).

- Thermometer with accuracy of $\pm 1°C$ or better

- Water purification system capable of producing deionized water with a resistivity greater than or equal to 17.5 megohm-cm (calibration not required; see Section 6.3.2).

- Potassium chloride (KC1), ACS reagent-grade, used for preparation of standards.

6.2.1 Equipment Malfunctions

Any equipment malfunction occurring during implementation of this procedure is likely to be readily detectable in the course of conducting work; therefore, it is not expected to have a detrimental effect on the final results. The water purification system has a meter that indicates the resistivity of the purified water. This meter is checked prior to use by the user to verify that the resistivity is within the range of acceptable values, i.e. greater than 17.5 megohm-cm. If a problem arises which can be considered a potential source of error or uncertainty for the results, then it is addressed in Section 6.7.

6.2.2 Safety Considerations

Good laboratory and scientific practices are used to protect against injury. Applicable LANL and/or LANL-subcontractor safety practices for conducting laboratory work are followed.

6.2.3 Special Handling

Analytical standard solutions should be stored in the refrigerator when not in use in order to minimize potential loss due to evaporation and to prevent a change in conductivity due to loss or gain of dissolved gases.

6.3 Preparatory Verification

6.3.1 Hold Points (N/A)

6.3.2 Calibration

The analytical balance is controlled pursuant to QP-12.3. The conductivity meter is calibrated by the user following the procedure described in section 6.5.3.1 of this DP. The water purification system does not require calibration because the purpose of its meter is limited to alerting the user to a failure of the system to produce deionized water, as indicated by the reading on the resistivity meter. Meter failure is indicated by a "zero" reading, at which time the meter is replaced by the vendor.

6.3.3   Environmental Conditions

Work is conducted at room temperature, under normal laboratory conditions of cleanliness.

6.4   Control of Samples

It is imperative that sample identification and control be sufficient to trace a sample and its derivative from its original field location to the point of analysis and that the integrity of the sample be safeguarded during the entire analytical process. Consequently, users must be trained to DP-103 before they can work with samples analytically and they must also follow guidelines set forth in that document for sample control.

6.5   Implementing Procedure

6.5.1   KC1 Standard Solution

The user conducts the following steps, as necessary, to prepare the standard solution used in this DP.

6.5.1.1   Preparation

Prepare a standard solution using KC1 salt. Prior to weighing, oven-dry the salt at a temperature of 150°C for 2 hours or until weight loss is less than 1%. Cool and store in a desiccator. Prepare the standard by dissolving dry KC1 in the appropriate volume of deionized water to obtain the desired solution strength (see following table). Weights should be recorded to the extent necessary to obtain a precision of 1% or better.

Table of KC1 Concentrations and Corresponding Conductivities

Concentration	Oven-dry KC1 mass	Volume of water	Conductivity at 25°C
1M	74.25 g	1 L	111.3 mS/cm
0.1M	7.425 g	1 L	12.85 mS/cm
0.01M	0.742 g	1 L	1.408 mS/cm

NOTE: This table is merely a guideline. The user may choose to prepare or purchase commercially available, certified KC1 standards with different concentrations and volumes than those listed above.

6.5.1.2   Labeling

Label the storage container for each standard solution with its unique identifier, concentration, date of preparation, and preparer's initials. The expiration date for the standard solution is six months after preparation. The expiration date for a commercially-available certified stock solution is specified on the certificate of analysis.

6.5.1.3   Storage

Refrigerate each solution in a capped or stoppered bottle or flask when not in use.

6.5.1.4   Documentation

Documentation of these consumable standards is governed by QP-12.3. Record the required information in a laboratory notebook or logbook. See Attachment 1.

6.5.2   Initial Set-Up

The user conducts the operations listed in this section. No documentation of these steps is required.

6.5.2.1   Standard Solutions

Ensure that the standard solutions have been brought to room temperature before working with this DP.

6.5.2.2   Conductivity Meter

Ensure that the meter is in good working order. The meter should not be dirty or have crusted material on the probe and the batteries should be charged (if necessary).

6.5.2.3   Samples

Samples consist of aqueous solutions of sufficient volume to completely immerse the conductivity probe. If applicable, any sample preparation shall be documented in the logbook or notebook. Solutions are brought to room temperature before analysis.

6.5.3 Analysis of Samples

6.5.3.1 Initial Calibration

Measure the temperature to the nearest 1°C of the KC1 standard solution(s) prepared in Section 6.5.1. Turn on the meter. Adjust the Sample Temperature Input to the measured solution temperature. Adjust the Conductivity Range Selector to the appropriate setting. Rinse the conductivity probe thoroughly with deionized water, and then measure the electrical conductivity of the standard solution. Record the information listed as required in Attachment 1. The user must utilize at least one standard solution that is within an order of magnitude of the conductivity of the samples being analyzed. A one-point calibration is adequate for the purposes of this DP.

6.5.3.2 Sample Conductivity Measurement

Rinse the probe with deionized water, immerse it in the sample solution, record the reading and rinse the probe.

6.5.3.3 Calibration Checks

Conduct a calibration check every 10 samples by immersing the probe in the KC1 standard solution used for the initial calibration. If the reading is within 5% of the expected value, continue with sample analyses. Otherwise, proceed to Step 6.5.3.4.

6.5.3.4 Calibration Drift

If a calibration check is off by more than 5%, then recalibrate the meter following Step 6.5.3.1. Recheck the previous 10 samples to verify readings. Perform another calibration check and continue with subsequent samples. If recalibration does not correct the meter, consult the manufacturer's manual for troubleshooting guidelines.

6.5.3.5 Documentation

Record all information listed as required in Attachment 1.

6.5.4 Completion of Sample Analyses

When analyses are completed, the user rinses the probe thoroughly, turns the power off, returns the working standard to the refrigerator and the probe to its storage place.

6.6 Data Acquisition and Reduction

Conductivity measurements are recorded to four significant figures. Data are acceptable if the calibration checks are within 5% of the expected value.

6.7 Potential Sources of Error and Uncertainty

Errors due to temperature shifts are minimized by frequent calibration checks and recalibration of the meter as needed. Attention to labels on sample containers and in recording data reduces error in mislabeling. The possibility of cross-contamination is reduced by working in a clean environment. If a problem arises which can be considered a potential source of error or uncertainty for the results, then it is documented in the laboratory notebook in accordance with QP-03.5.

7.0 RECORDS

Proper execution of this DP results in entries into a scientific notebook or logbook. Attachment 1 lists the information required to be documented. Entries are made in accordance with QP-03.5. The notebooks or logbooks are submitted as record packages to the Records Processing Center in accordance with QP-17.6.

8.0 ACCEPTANCE CRITERIA

The criteria showing that this procedure has been properly implemented are the records generated in Section 7.0.

9.0 TRAINING

This DP requires "read-only" training. Training of personnel to this DP is documented pursuant to QP-02.7.

10.0 ATTACHMENTS

Attachment 1: Checklist of Laboratory Notebook Entries

CHECKLIST OF LABORATORY NOTEBOOK ENTRIES

Initial descriptive information is entered in the laboratory notebook as appropriate prior to starting a technical procedure and on a continuing basis as experimental and procedural changes dictate. These entries include:

– reference to this DP, including revision number

Parameters that need to be recorded for a KC1 standard solution, whether prepared in the laboratory or purchased from an outside vendor, are governed by QP-12.3. Required entries are as follows:

– chemical reagent, manufacturer or supplier and lot number
– date of preparation or receipt
– unique balance identification number and calibration expiration date (if used)
– mass of KC1 used, recorded to precision of 1% (not necessary for commercially-prepared standard)
– volume of water, to the nearest mL (not necessary for commercially-prepared standard)
– unique identifier assigned to standard solution
– solution concentration and estimated uncertainty
– certificate information (if applicable)
– solution expiration date
– designated usage on LANL YMP (i.e., calibration of conductivity meter)
– custodian and storage location (LANL technical area, building and room)
– date and reason for removal of standard from LANL YMP control system, with PI signature and date
– user's signature and date

Required information regarding initial calibration, sample analysis, calibration checks, is as follows:

– date of analysis
– unique sample identification numbers assigned per DP-103
– measured conductivity of samples and standards in order of analysis
– conductivity meter unique identification number
– KC1 standard unique identification number
– KC1 standard concentration
– temperature of aqueous sample solution
– user's signature and date

Finally, the user must record problems, if any, which could be considered potential sources of error or uncertainty for the results.